# ELECTRICAL CABLE TERMINAL PART STRUCTURE AND TREATMENT METHOD

## BACKGROUND OF THE INVENTION

The present invention relates to an electrical cable that is terminated to an electrical component and a method for preparing such cable for termination. More specifically, the invention is related to an electrical cable and method for termination for high-speed signal transmission.

## DESCRIPTION OF THE PRIOR ART

Shielded electrical wire cable and coaxial cable are commonly used for high-speed signal transmission, and more specifically, high-speed digital differential transmission. However, the method and structure by which these cables are terminated to the components can vary. In one conventional termination structure, disclosed in Japanese Patent Application Kokai No. H10-223051, the intermediate portions of two sheet-form shielded electrical wires are bundled into a single unit by means of a tape or heat-shrink tube. Both end portions of the wires, exposed for the purpose of branching, are shielded by shielding layers of the respective electrical wires themselves. In another conventional structure, disclosed in Japanese Patent Application Kokoku No. S56-24447, a coaxial cable wrapped with a cordel braided insulator is stripped when a metal contact plug fastening fitting is attached to the terminal part of the coaxial cable. The exposed inner conductor is covered with a tightly adhering heat-shrinkable plastic tube to form a dielectric layer. The length and thickness of the dielectric layer can be arbitrarily set in order to adjust the characteristic impedance of the internal conductor.

In the first recited reference the end portions of the shielded electrical wires are merely shielded in the

shielded electrical wire terminal treatment structure and, therefore, impedance matching cannot be maintained. Further, because impedance matching is accomplished by means of a heat-shrink tube in the coaxial cable method, recited in the second reference differential transmission signal wires are not accounted for. Thus, in these conventional methods, the individual differential transmission signal wires and drain wire from which the shielding covering has been stripped are generally connected to a corresponding circuit board, etc., in a loose state, i.e., in a state in which the positional relationship of the electrical wires is not maintained. The end portion of the shielding covering and the portion of the drain wire that is exposed from the end portion are separately covered by tightly adhering heat-shrink tubes. For that reason, the characteristic impedance of the exposed differential transmission signal wires is not matched causing problems such as signal reflection and signal deviation. This terminal treatment is expensive and time consuming.

It is therefore desirable to develop an inexpensive electrical cable structure and method where the matching (balance) of the differential impedance between the two differential transmission signal wires and the drain wire is maintained so that there is little signal reflection when the cable is terminated to an electrical component. It is also desirable to develop a structure and method that is suitable for use in high speed transmission and prevents deterioration of the transmission characteristics by eliminating skewing (propagation delay time difference, i.e., signal deviation) between the two signal wires.

## SUMMARY OF THE INVENTION

The invention relates to an electrical cable terminal part structure having two differential transmission signal wires. An insulator covers the respective core wires. A

single drain wire is disposed adjacent to the differential transmission signal wires at an equal distance from each of the differential transmission signal wires. A shielding covering surrounds the wires. The area around the two differential transmission signal wires and the drain wire are exposed at a terminal part or front end of the electrical cable by stripping the shielding covering. Except for the exposed front end portions of the differential transmission signal wires and drain wire, the area around the two differential transmission signal wires and the drain wire is covered by a heat-shrink tube together with the end portion of the shielding covering, so that mutual distances between the wires inside the cable are maintained.

This invention also relates to a method in which the two differential transmission signal wires and the drain wire are exposed by stripping the shielding covering at the terminal part or termination end of the electrical cable. The area around the two differential transmission signal wires and the drain wire that are exposed is covered with a heat-shrink tube together with the end portion of the shielding covering. Only the front-end portions of the differential transmission signal wires and drain wire remain exposed so that mutual distances between the wires inside the electrical cable are maintained.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of example with reference to the accompanying drawings wherein:

Figure 1 is a perspective view of a cable terminal part where a shielding covering has been partially stripped away.

Figure 2 is a cross-sectional view of the cable terminal part taken along the line 2-2 of Figure 1.

Figure 3 is a perspective view of the cable terminal part shown in Figure 1 where the electrical cable is tightly covered by a heat-shrink tube.

Figure 4 is a perspective view showing signal wires connected to conductive pads on one side of a board.

Figure 5 is a perspective view showing a drain wire connected to the conductive pad on a second side of the board.

Figure 6 is a front view of a male connector with the board showing one example of an application of the electrical cable terminal part structure and method.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 shows an electrical cable 1, generally known as a shielded twisted pair cable, suitable for use in high-speed digital differential transmission. The cable 1 has three electrical wires W disposed inside a shielding covering 3. The cable 1 is stripped to expose the end portions 10 of the electrical wires W, i.e., the end portions 10 of the signal wires 4 and 6 and drain wire 8, over a given length. The end portion of the shielding covering 3 is stripped by holding an end portion 10 of the cable 1 with a holding tool (not shown).

As a result of the stripping, in the case of the signal wires 4 and 6, the impedance between the exposed end portions 10 and the portions of the signal wires 4 and 6 that are inside the shielding covering 3 is no longer matched. The method used to adjust the impedance will be described later.

Figure 2 shows the internal structure of the cable 1 in a region where the cable has not been stripped. The shielding covering 3 has an insulating outer layer 3a that consists of a polyester film. An aluminium foil (ground conductor) 3b covers the inside surface of the outer layer 3a. The three electrical wires W that are disposed inside

the aluminium foil 3b consist of differential transmission signal wires 4 and 6 and a drain wire 8. The differential transmission signal wires are signal wires which are devised so that signals are transmitted by inputting voltages whose phases are reversed into two transmission wires. The three electrical wires W are twisted together and disposed inside the shielding covering 3 of the cable 1. The signal wire 4 and signal wire 6 have respective core wires 4a and 6a covered with an insulating outer covering 4b and 6b consisting of a polyolefin-type resin.

The drain wire 8 is a naked electrical wire and may be a single wire or a plurality of copper wires twisted together to form a single wire. The drain wire 8 is positioned in close proximity to the signal wires 4 and 6, and at an equal distance from each of the signal wires 4 and 6. Equal distance includes cases in which the distances are slightly different due to dimensional error or manufacturing error of the electrical wire or deformation, etc., of the electrical wires, in addition to cases in which the distances are completely identical. The distances of the three electrical wires W from each other are maintained as fixed distances inside the shielding covering 3. Specifically, the drain wire 8 is located in a position that is separated from the core wires 4a and 6a of the signal wires 4 and 6 by a distance corresponding roughly to the thickness of the outer coverings 4b and 6b of the core wires 4a and 6a.

The sectional view shown in Figure 2 indicates the theoretical shape of the cable structure. In actuality, however, because of dimensional error, manufacturing error or deformation, etc., of the members, the positional relationship is not accurately maintained as a fixed relationship. Further, the drain wire 8 is accommodated in a state in which the drain wire 8 contacts the aluminium foil 3b. The signal wire 4 and signal wire 6 constitute so-

called equilibrium wires which are loaded with a voltage so that the magnitude of the voltage is equal and of opposite polarity with respect to the ground point in an arbitrary cross section.

Because the impedance of the exposed terminal part 10 of the cable 1 is mismatched with the impedance of the signal wires 4 and 6 inside the shielding covering 3 of the cable 1, a plastic heat-shrink tube 12 is caused to adhere tightly to the terminal part 10 and shielding covering 3 (Figure 3). The front-end portion 14 of the terminal part 10, however, remains exposed. The plastic shrink tube 12 maintains equal distances between the drain wire 8 and the respective signal wires 4 and 6. As a result, the heat-shrink tube 12 prevents or alleviates mismatching of the differential impedance and maintains the balance among the electrical wires W, eliminating skewing, i.e., signal deviation, between the signal wires 4 and 6. Further, since impedance mismatching can be kept to a minimum, reflection is reduced.

The connection of the cable terminal part to an electrical component, i.e., a circuit board, will be described with reference to Figures 4 and 5. The exposed front-end portions 14 of the signal wires 4 and 6 are disposed on a first side, i.e., an upper side 20, of a board 16. The drain wire 8 is disposed on a second side, i.e., an underside 22, of the board 16. In this case, since the signal wires 4 and 6 and drain wire 8 are flexible, the wires can be divided between the upper and lower surfaces of the board 16. The drain wire 8 and the exposed core wires 4a and 6a of the signal wires 4 and 6 are then respectively fastened by soldering to conductive pads 24, 18, 18. The conductive pad 24 is positioned at an intermediate point between the conductive pads 18, 18 on the opposite side of the board 16 (Figure 5).

In Figures 4 and 5, only one cable 1 is shown for purposes of description. In actuality, however, a plurality of cables are lined up side by side, with the connecting parts of the signal wires 4 and 6 and drain wire 8 alternating between the first side 20 and the second side 22 of the board 16. Adjacent cables 1 are connected to the conductive pads 18 so that the same polarities (phases) are adjacent to each other between the respective cables. As a result, crosstalk can be prevented.

One example of an application of the present invention is shown in Figure 6. Figure 6 is a front view of a male connector (plug connector) having a board 16 disposed with cables 1. A rectangular opening 34 is formed facing rearward in the housing 32 of the male connector 30. A pair of ribs 36, 36 are formed on the inside surfaces of the opening 34 so that the ribs protrude facing each other across the entire width of the opening 34 in a direction perpendicular to the direction of insertion of the male connector 30. A slot 38 formed between the ribs 36, 36 extends across the entire width of the opening 34. A board 16 having numerous contacts 40 is inserted and held in the slot 38. Because it is sufficient if the contacts 40 have electrical continuity with the conductive pads 18, 18, 24, the contacts 40 are disposed on both surfaces of the board in a positional relationship. The tip end portions of the contacts 40 are exposed inside the opening 34 and constitute contact parts that make contact with the contacts of a second connector (not shown) that is engaged with the male connector 30.

While the present invention has been described in connection with the illustrated embodiments, it will be appreciated and understood that modifications may be made without departing from the true spirit and scope of the invention. For example, it would also be possible to install the conductive pads 18, 18, 24 on the same side of

the board, and to connect the three electrical wires W of each cable 1 to these conductive pads.